Swami Ramanand Teerth Marathwada University,Nanded

Name of research topic :

“Effect of dopant element on structural, electrical and magnetic properties of hexagonal Ferrite”

Name of Research Scholar: Mr. Mundhe Mangesh Tanaji

M.Sc. SET (Physics)

Mob. No. 8999152071

E-mail: mangeshm915694@gmail.com

Category: NT-D(Vanjari)

Name of Research Guide

Dr. R. A. Kunale

Assistant Prof. and Head of Physics Department

Kai. Rasika Mahavidyalaya, Deoni

Tq. Deoni, Dist. Latur-413519 (M.S.)

Mo. No. 860656959

E-mail: kunalerenuka9@gmail.com

2024

Topic name: Effect of dopant element on structural, electrical and magnetic properties of hexagonal Ferrite

1. Introduction:

Ferrite are magnetic materials with iron oxide as a main component. Ferrite have attracted intense interest in fundamental science, especially for addressing the basic relationship between magnetic properties and their crystal chemistry. They have been extensively investigated in recent years for their useful electrical and magnetic properties and applications in information storage systems, magnetic bulk cores, magnetic fluids, microwave absorbers and high frequency devices [1, 3]. Ferrites are much used by the modern electronics industry due to their high electrical resistivity, high values of magnetic permeability, low dielectric loss, together with high mechanical strength, good chemical stability, and low coercive value [4]. Ferrites are classified in to three types such as spinel, garnet and hexaferrites. Hexaferrites are classifified into five types depending on their chemical and crystalline structure. These include M, W, Y, X and Z type hexaferrites. Barium and strontium hexaferrites lie among the M-type class of hexaferrites which possesses a general formula M-$Fe_{12}O_{19}$. Barium ferrite widely used as a hard magnetic material for permanent magnets since its first introduction by Philips [5]. Their magnetic properties arises from interactions between metallic ions occupying particular positions relative to the oxygen ions in its hexagonal

crystalline structure. Ba-ferrites have been used in various components for application at high frequency [6, 7]. Recent studies have been focused on the synthesis of nano crystalline powders in order to improve magnetic properties with increasing the surface area. Strontium ferrite powders are ideal fillers for the development of electromagnetic attenuation materials at microwave, due to their low cost, low density, high stability, large electrical resistivity and high microwave magnetic loss [8].

2. **Literature review**

In the recent years, technology with ferrites materials has reached a very advanced stage. Materials engineers can control the various properties of ferrites by changing the synthesis routs, preparative conditions and starting materials in order to achieve the particular purpose. Due to the overwhelm ing physico-chemical properties, mixed ferrites have attracted wide scientific attention to prepare these materials at low cost and low temperature. By selecting the proper synthesis route, basic constituent elements and preparation conditions ferrites can be prepared for a specific application. Nano structured ferrites have very wide applications in industry, research and technology, and medical fields [9]. Literature reviews suggest that the substitutions of magnetic/non-magnetic ions dopants in simple and mixed ferrites have received a great deal of interest. To date, several research works have been carried out to improve the magnetic properties of Sr-hexaferrite, by substitution of magnetic and non-magnetic ion dopants such as Co^{2+}, Mn^{2+}, Sn^{4+}, Zr^{4+} , and Zn^{2+} in the Fe^{3+} site in hexaferrite structure [10–13].

M-type barium ferrite with a hexagonal structure $BaFe_{12}O_{19}$ is a famous high-performance permanent magnetic material on the account of its large magneto crystalline anisotropy, high Curie temperature, relatively large magnetization, outstanding chemical stability, and corrosion resistivity [14-19]. Several researchers have reported their results on the structural, magnetic and modified microwave properties of substituted Ba-hexaferrites by changing the substituted ion and its concentration such as Ce-Co, Co-Ti, La-Co [20-22]. The presence of these ions in ferrites is found to alter their structural, magnetic and electrical properties.

3. **Objective of the present work**

The objective of this study is to prepare magnetic materials having excellent coercive field (H_c), magnetization and stability (chemical and physical). Magnetic and electric properties of high purity magnetic materials are of great importance due to their variety of application in various fields. The study of magnetic materials with substitution of different magnetic or nonmagnetic ion dopants is extremely important for advancement of magnetic and electric properties. Following objective has been set to attain destination of the present work.

1] To synthesis mixed metal oxide systems by chemical method.

2] To investigate the phase formation and structural parameter by

- X-ray diffraction technique (XRD)
- Transmission electron microscopy (TEM)
- Scanning electron microscopy (SEM)

- Infrared spectroscopy (IR)

3] To study magnetic properties by

- Vibrating sample magnetometer (VSM)

4) To study the electrical properties such as

- Dielectric properties
- D.C. resistivity

4. Methodology:

We will use chemical route to prepare the proposed samples in nanometer dimensions. To examine phase formation of the prepared sample, it is necessary to characterize the samples by XRD technique. Using XRD data the lattice parameter, X-ray density and particle size will be evaluated. The particle size of newly prepared samples will also be determined by transmission electron microscopy (TEM). The Infrared spectroscopy (IR) patterns will be used to study bond formation.The saturation magnetization (Ms), Coercivity, and retentivity will be measured using vibrating sample magnetometer (VSM).

The dielectric properties such as dielectric constant, dielectric loss and dielectric loss tangent as a function of frequency will be carried out at room temperature on LCR-Q meter. D.C. electrical resistivity measurements of all the samples in the form of pellets will be carried out in the temperature range 300 to 800 K by two probe technique.

References:

[1]M. A. Rehma, F. Zahra1, S. Kanwal, Z. Khan, A. Asif, Anam Noor Hussain, Saba Zahid, J Mater Sci: Mater Electron (2015) 26:6539–6545

[2] J. L. Dorman, D. Fiorani (Eds.), Magnetic Properties of Fine Particles, Amesterdam, North-Holland, 1992.

[3] E.S. Murdock, R.F. Simmons, R. Davidson, IEEE Trans. Magn. 28 (1992) 3078.

[4] V. Uskokovic, M. Drofenik, I. Ban, J. Magn. Magn. Mater. 284 (2004) 294.

[5] J. Smit, H.P.J. Wijn, Ferrite, Philips Tech. Lib., Eindhoven, 1960.

[6] P. Campbell, Permanent Magnet Materials and Their Application, Cambridge University Press, Cambridge, 1994.

[7] H. Kojima, in: E.P. Wohlfarth (Ed.), Ferromagnetic Materials, 3, North-Holland Publ. Comp., Amsterdam, 1982 (Chapter 3).

[8] Z. Zhang, X.Liu, X.Wang, Y.Wu, R.Li, J. Alloys Compd .525(2012)114–119.

[9]I. A. Auwal, B. Unhal, H. Gungunes, S. E. Shirsath, A. Baykal;Ceram. Inter.

42 (2016) 9100-9115.

[10] Q. Fang, Y.Liu, P.Yin, X.Li, J.Magn.Magn. Mater. 234(2001)366–370.

[11] M. J. Iqbal, M. N. Ashiq, P. Hernandez-Gomez, J. M. Muñoz, C.T. Cabrera, J. Alloys Compd. 500(2010)113–116.

[12] A. Ghasemi, X. Liu, A. Morisako, IEEE Trans. Magn. 45 (10) (2009) 4420–4423.

[13] Akanksha Gupta, P. K. Roy, inorganic chemistry communications, Vol 155 (2023) 111114.

[14] S. G. Kim, etal., J. Phys. Chem. C 111(28)(2007)10175–10180.

[15] T. Yamauchi, etal., J. Magn. Magn.Mater. 321(1)(2009)8–11.

[16] S. Singhal, etal., Ceram. Int. 37(6)(2011)1833–1837.

[17] M. Drofenik, etal., Mater. Chem. Phys. 127(3)(2011)415–419.

[18] C.J. Li, B.Wang, J.N.Wang, J. Magn. Magn. Mater. 324(7)(2012)1305–1311.

[19]M. K. Manglam etal, Applied Physics A,(2021) 138.

[20]Z.F. Zi, Q.C. Liu, J.M. Dai, Y.P. Sun, Solid State Commun. 152 (2012) 894e897.

[21]C. Dong, X. Wang, P. Zhou, T. Liu, J. Xie, L. Deng, J. Magn. Magn. Mater. 354 (2014) 340e344.

[22] J. Li, H. Zhang, Q. Li, Y. Li, G. Yu, J. Rare Earths 31 (2013) 983.

Research Student

Mr. Mundhe Mangesh Tanaji

M.Sc. SET (Physics)

Research Guide

Dr. R. A. Kunale

Assistant Prof. and Head of Physics Department

Kai. Rasika Mahavidyalaya, Deoni

Tq. Deoni, Dist. Latur-413519 (M.S.)